Antoine Pilon
Head Of UERF prevention & protection team

AIRBUS rotorburst structure assessment

AAWG face to face meeting,
Everett, 14/15 March 2016

Content

1) Introduction

- Context : AAWG task on rotorburst

Major objective: Review existing material and make a recommendation/ proposal with respect to addressing 25.571(e) and associated guidance material (AC 25-571-1D, AC 20-128A, FAA Policy Statement ANM-1993-0041) as they pertain to uncontained engine failures

- Goal of presentation:

Structure rotorburst assessment - awareness for AAWG on how Airbus:

- Show compliance to 25.571(e) and 25.903(d) for UERF
- Design minimize consequences in case of rotorburst

Note: UERF (Uncontained Engine Rotor Failure) = Rotorburst

2) Methodology / process

Airbus approach:

"Design precautions must be taken to minimise the hazards to the aeroplane in the event of an uncontained engine rotor failure …"

FIRST

MINIMIZE RISK:

« Design precautions »

(demonstrate precautions are taken up to industrial feasibility limits)

THEN

QUANTIFY REMAINING RISK:

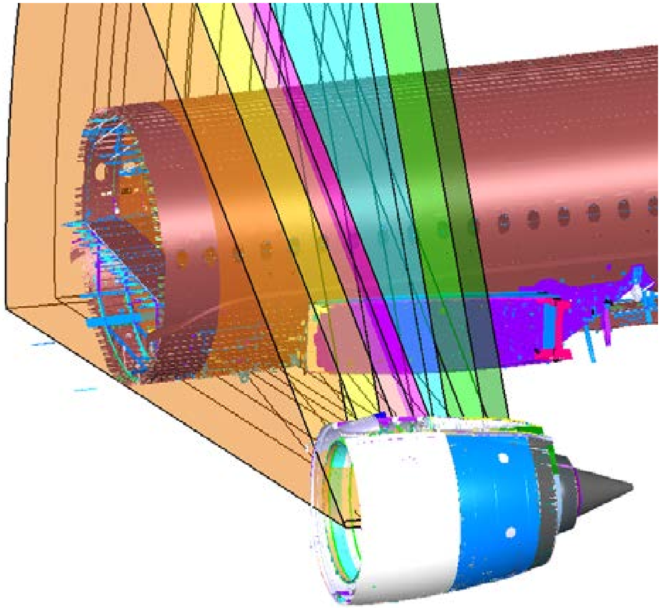
« 1/20 Risk Analysis »

(1 out of 20 UERF events CAT is considered as an acceptable indicator that the risk has been minimized)

2) Methodology / process

High level design precaution process:

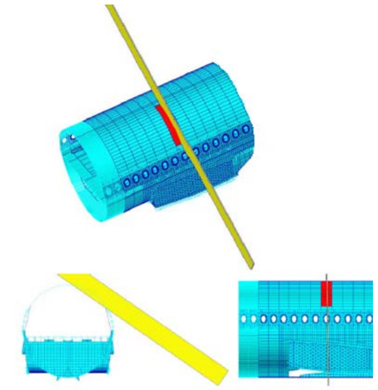
- Engine manufacturer provides engine data
- Engine integration team generates UERF model of 1/3rd disc and other fragments as per AC/AMC 20.128A.
- Engine integration team determines UERF risk areas to be considered for design precautions
- Structure teams assess aircraft considering this threat

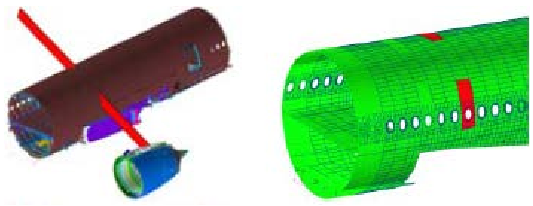


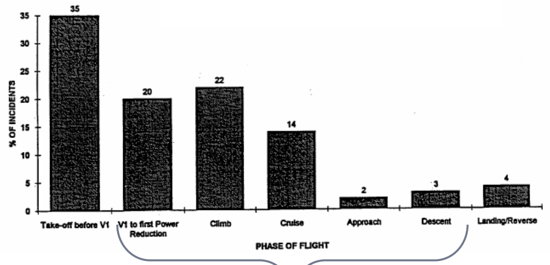
2) Methodology / process

Process for residual risk evaluation:

- Engine integration team provides typical trajectories to be analyzed to structure teams
- Those “cuts” are introduced in FEM models
- Structure team analyzes whether the damaged airframe can sustain GHL
- Not sustainable cuts are classified CAT and are then translated into criteria (X stringers between frames Y & Z for instance)
- Engine integration team integrates those CAT criteria into the A/C level residual risk computation:
  - Structural failure considered CAT only in airborne phases (risk considered null on ground)
  - Overall A/C analysis integrates other CAT contributors such as fire, thrust loss, systems…
  - Overall aircraft figure to not exceed 1/20 in average and 1/10 per stage





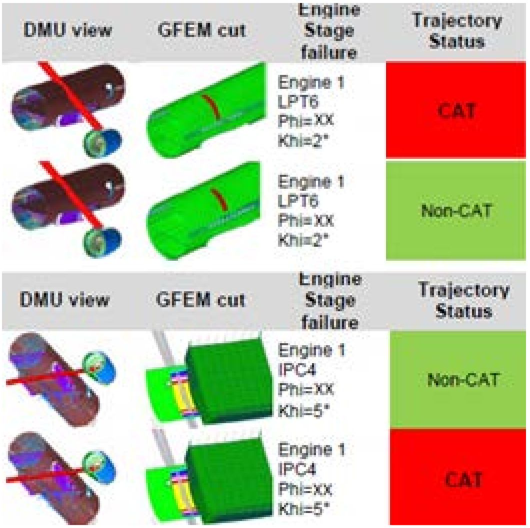


Phases of flight where structural failure is considered CAT

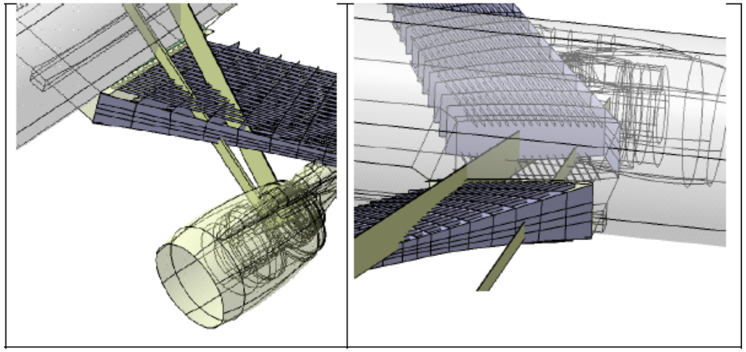
2) Methodology / process

Example of critical damages presentation:

- Upper / Lower shell: XX stringers



- Outer wingbox
  - XX portion of front spar
  - XX number of ribs
  - XX number of covers stringers
  - Or combination of those



Example Intersections between 1/3-Disc Fragment Trajectories & the Wingbox

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2) Methodology / process

- Several loops of analysis are done during the A/C development. If results are exceeding the acceptable level, analysis are refined with less conservatism.

- Flutter: Aero-elasticity assessment is performed taking into account non-catastrophic cuts to check compliance.

3) Minimization practices

Design is driven by static strength, fatigue and flutter criteria but many design principles serve robustness to UERF threat.

Key design features to minimize extent of damage after UERF:

- Use of high fracture toughness material
- Multiple Load Path design
- Parts assembly (stringers/frames/ribs)
- Stiffener(s) on the inner front spar

As a result design has damage tolerance capability which minimizes risk of failure following an UERF.

Note that catastrophic cases for the structure are generated by such extreme damages that further reasonable design precautions are difficult to imagine and will be hardly effective.

4) Synthesis

- Design precautions to minimize the risk of hazard after a rotor burst are taken:
  - Structural design principles ensure an inherent robustness against UERF threat
  - In service experience has proven them to be effective

- Compliance to 25.571(e) is shown via 25.903(d) by description of design precautions and identification of outstanding critical scenarios feeding the aircraft level residual risk analysis

- As per AC/AMC 20.128A, the aircraft risk analysis showing that an acceptable level of safety is achieved includes the structural contribution